THE UNIVERSITY OF ALBERTA

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by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled:

The design of didactic play materials
intended to stimulate the development of creativity
in children aged three to twelve.

Submitted by: Jonathan Aitken

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CONTENTS

ABSTRACT

This report documents the design of a group of didactic play materials intended to stimulate creative play in children aged three to twelve. It includes a summary of the relevant studies and other research in the area of play and creativity. Some of the problems with contemporary toys are examined in the summary, and the scope of this design project is outlined. Design criteria are established, and the design process is documented from the initial concept, through prototyping and testing, to the final design. Manufacture and marketing of the final product are briefly examined.

Chapter 1: SUMMARY OF RESEARCH

Hypothesis

Certain elements in children's play have been shown to be closely related to the development of creativity (Lieberman 1965, Sutton-Smith 1967, Rubin 1983, Weininger 1980, Jeanrenaud and Bishop 1980, Singer 1973, Bloch 1984, McLoyd 1985). If these elements can be given special emphasis through the use of specific didactic play materials, then creativity can be stimulated in children through play.

Introduction

This hypothesis has been formulated after considering the research of many experts in the fields of psychology, child development and education. Specific writings and publications were studied which examined play, play materials, child development, creativity, and methods of stimulating creativity. A summary of this research is given here to lend support to the proposed design criteria. In the following section the relationship between play and creativity is outlined and the problems inherent in defining and measuring creativity are examined. In the next section a working definition of creativity is given, and certain play variables that have been found to stimulate creativity are discussed. Further sections include a discussion of some contemporary play materials, an explanation of the proposed scope of the design project, and finally, a conclusion.

Play and Creativity: Problems of Measurement

The relationship between play and child development has been well documented, but opinions vary greatly as to what specific form that relationship takes. However, there does seem to be general agreement among child psychologists that development is a function of the interaction between children and their environment (Singer and Singer 1969, Piaget 1954, Sutton-Smith 1967). From this basic assumption, psychologists have conducted studies and experiments to determine specific play elements that affect certain aspects of development. One such area of research is the relationship between play and creativity.

The difficulties in detecting the specific elements of play that affect creativity are twofold. First, a working definition of creativity is essential to any study of the area, but the term is difficult to precisely define. Some experts, such as Thomson (1969) or Stein (1975), emphasize that aspect of creativity which results in a product. Stein goes further still and says that "Creativity is

a process that results in a novel product or idea which is accepted as useful, tenable, or satisfying by a significant group of others at some point in time" (Stein 1975, p.253). But this view of creativity ignores the question: products useful to whom and judged by what standards? Others put more emphasis on creativity as a process. In his notable work on the subject, The Act of Creation, Arthur Koestler explains the creative moment of insight as "the perceiving of a situation or idea in two self-consistent but habitually incompatible frames of reference" (p.35). By placing the emphasis on perception rather than production, Koestler shows that creativity can be considered as a way of thinking.

Most psychologists would agree with this emphasis on the process of creativity (Arasteh 1968), rather than on its products, but even here there is disagreement. For example, the bulk of Edward de Bono's work is directed towards creative problem solving. He distinguishes between creativity and lateral thinking, calling the latter the process of generating new ideas (1977). Torrance (1970) sees creativity as a life skill essential for coping with stress, and even links schizophrenia to an individual's lack of creativity. Day (1968) states that psychoanalytic theory explains creativity as the sublimation of repressed impulse.

Measuring creativity is even more difficult than defining it. Faced with the dilemma of testing for something which they cannot define, psychologists have developed tests to measure those specific aspects of creativity which are in fact measurable: field independence, fluency, flexibility, divergent thinking, fantasy, imagination, originality, or nonconformity. But the tests reflect their authors' own perceptions regarding the nature of creativity (Treffinger et al 1970), which, as discussed, vary greatly. For this reason, the results of studies and tests purportedly measuring "creativity" are open to interpretation and methodological criticism. As well there is some question as to whether creativity is empirically distinguishable from other cognitive processes (Treffinger et al 1970). For example, does a test of creativity measure something significantly different from tests for I.Q. or academic achievement? Finally, there is the problem of outlining external criteria against which the validity of creativity tests can be measured (Treffinger et al 1970). Although creative people may share some personality traits, there seem to be no consistently distinguishable characteristics which separate creative people from uncreative ones.

Play Factors Affecting Creativity

The problems involved both in defining creativity and testing for it have made it difficult to interpret the results of relevant studies. For the purposes of gathering information from a number of studies in order to outline design criteria for play materials, it is important that a working definition of creativity be agreed upon. Perhaps one of the most useful definitions is given by

Jeanrenaud and Bishop (1980, p.77), who state that "Creativity is the production of novel responses that have an appropriate impact in a given context." This definition is helpful because it embraces the process, or act of being creative, while requiring as well an appropriate effect. The definition thereby rejects the generation of ideas as the sole criteria for creativity by incorporating the concept of judgement in determining an idea's potential appropriateness. This definition, however, is not all-encompassing, but gives us a basis from which to consider the implications of several studies pertinent to this thesis (see Bibliography). These studies will be examined here for the purpose of isolating play variables that are seen to affect creativity. In a later chapter these variables will be used to generate a set of design criteria for play materials that will help to stimulate creativity in children. All of the studies discussed here examine the relationship between one specific play variable and the development of creativity in children. For the sake of convenience, they have been grouped according to the variable that they examine: pretend play, low/high structure toys, construction toys, exploration, scale of materials, adult supervision, and age.

Many psychologists have indicated a positive correlation between pretend play and creativity (Lieberman 1965, Smilansky 1968, Rubin 1983, Singer 1973). In these studies it has been found that the facility of children to be imaginative in fantasy play is related to their performance on tests of divergent thinking. The ability of children to "imagine" seems to coincide with their ability to produce novel responses, one aspect of creativity.

Others have examined the different types of play that are stimulated by low and high structure toys. Generally, low structure toys (toys characterized by a lack of inherent "realness") are considered to be more conducive to the development of creativity than high structure or "replica" toys (Philips 1945, Smilansky 1968, Weininger 1980, Caplan 1973, Pulaski 1970, Bloch 1984, McLoyd 1985, Ellis 1972, van Alstyne 1932). The reason for this is that high structure toys are specific, encouraging one theme of pretend play only. On the other hand, non theme-specific low structure toys generate a diversity of pretend play themes. This diversity enriches pretend play, which as mentioned previously, relates to the development of creativity. One psychologist differs with this view; Rubin (1983), states that pretend play in toddlers seems to be aided by the presence of realistic toys. This apparent discrepancy might be explained by the possibility that younger children would initially benefit from the suggestiveness of realistic toys, but find their specificity restrictive as they grow older.

The role of construction toys in stimulating creativity has been examined by several researchers (Bailey and Burton 1982, Smilansky 1968, Rubin 1983, Ellis 1970, van Alstyne 1932, McDowell 1937). The relationship in this case seems clear, objects that can be recombined with other objects facilitate the construction of larger objects. In this way the child is encouraged to make novel responses by learning that there is no one "proper" way to

manipulate the materials.

Exploration in play has been observed by many psychologists, and its role is judged an important one (Jeanrenaud and Bishop 1980, Singer 1973). It is necessary to children for forming an understanding of their environment. The encouragement of exploration is important in developing a child's curiosity. Curiosity, according to Day (1968), is a precondition to creativity. He has hypothesized (and indicates research to support this hypothesis) that creative people are curious and prefer an environment that provides a high degree of collative variability. Many other studies have supported this idea, recognizing that in order to foster the growth of creativity an environment should provide: variability, novelty, surprise, uncertainty, conflict, choice, and as the child grows, increasing levels of challenge and complexity (Bailey and Burton 1982, Sutton-Smith 1967, Kritchevsky and Prescott 1969, Phyfe-Perkins 1980, Ellis 1970 and 1972). Nicholson's Theory of Loose Parts (1974) sums up this well: "In any environment both the degree of inventiveness, and the possibility of discovery, are directly proportional to the number and kinds of variables in it."

The scale of play materials in relation to the child is important. In one study (Smith and Conolly 1980) small toys were removed from a play area, leaving only large ones. The children became more sociable, more active, and more creative in terms of using the equipment in unusual ways. Bailey and Burton (1982) identified the need for a child to be able to move in relation to a structure. It was suggested by Caplan (1973) that too much play with small replica toys tended to encourage aggression and egocentricity in children, by teaching them that they could dominate a replica of the "whole world". This evidence would tend to support the use of large, child scale toys in stimulating creativity, though would not obviate the use of smaller toys.

Of importance to the design of play materials is knowing the type and amount of adult supervision and direction that will be present in playing with the materials. It has been found by even the earliest researchers (Piaget 1954) that children learn best by direct interaction with their environment. More recent studies (Haddon 1970, Weininger 1980) have found that an unstructured environment provides the best learning situation for a creative child. The reason for this is that in the unstructured environment there is an emphasis on self-initiated learning, certainly an important characteristic of creativity.

Finally, the age range of children for whom the play materials will be designed must be identified. This range can only be an approximate one as children may not neatly fall into any generalized level of development. Usually, though, before the age of three children are too concerned with consolidating their skills to benefit much from materials designed to stimulate creativity. But sometime after three years of age, children begin to indulge in pretend play (Smilansky 1968). By four, they begin to play

creatively and actively with materials (Caplan 1973). This continues for the next few years, peaks at about the age of six and begins to evolve into games with rules at about seven years (Rubin 1983).

Contemporary Play Materials

In order to place the proposed design project in context, it would be helpful to discuss some currently popular play materials. World toy production is valued today at 15 billion dollars (U.S.) annually (Sotamaa 1980). This huge industry is primarily dependent on mass marketing techniques made possible by television and the toys reflect this commercialism. Often influenced by, or directly copied from television programs, these toys are characterized by a "high structure" approach; they include replica dolls, theme role-playing kits, and model cars and trucks. Such toys are certainly popular with children, but as any parent can attest, interest in them is often short-lived. The specificity of these replica toys suggests one play theme only and as the child tires of repeating the same play theme, the toys are abandoned. But more important, this same specificity inhibits the development of the child's imagination by limiting the number of possible responses with the toys. By dictating play themes, these high structure toys discourage children from learning to invent their own.

Some contemporary toys are available that are more open-ended than those just mentioned. One of the most common examples, typical of a range of similar products, is Lego. A modular toy based on standard brick-like units, Lego can be used to construct an almost limitless variety of structures. It can be, and often is, used in an imaginative way to produce quite creative solutions. But this is not necessarily the case, for two reasons. First, Lego is now sold in kit form, each kit referring to a separate play theme. This contradicts the inherent non-specificity of the Lego units themselves, and discourages children from choosing their own play themes. A second obstacle to the creative use of Lego is the nature of the bricks themselves. They are rectilinear and can be connected only in a limited number of ways; the bricks at right angles or parallel to each other and always overlapped. The resulting structures are defined by these limitations and are characterized by a uniformity of construction technique and a certain similarity of appearance. Children quickly learn the few permutations possible with Lego and only within these limitations are they allowed to be imaginative. Play with Lego structures can be as imaginative as the child desires, but because of the rigid limitations of the connecting system, actual construction with Lego is limitedly creative.

Alternatives to commercially available toys are often found in schools. These school toys are often used as teaching aids in directed play to explain concepts to children, such as quantity or colour. One of the pioneers in this field of child education was Maria Montessori. In the early twentieth century she hypothesized

that play was the "work" of children to develop their inner selves and she designed specific didactic materials to assist that development. In designing these materials, Montessori first analyzed certain functions that she felt were important for children to learn. She then subdivided these functions into their component parts and invented task-oriented play experiences to teach the functions to children. She designed materials to guide these play experiences that were self-correcting; that is they could only be used successfully in one way. Blocks were not for constructing, but for stacking sequentially according to hue, value, or size. Pegs would only fit into their own predetermined holes according to size or shape. In this manner, children learned at their own pace and in their own way. They were not "taught" but learned through their own experience. The success of this method can be attested to by its widespread popularity. Children do learn what they are supposed to. But from the point of view of stimulating the development of creativity, the Montessori method is limited. It teaches analytical skills that are necessary for a child's cognitive development, but these skills do not directly relate to creativity as it has been defined in this report.

Scope of the Design Project

This design project attempts to fill a gap left by contemporary toys, by offering a group of play materials designed to stimulate the development of creativity in children. The overall design philosophy has been to encourage the natural inclination of children to manipulate their environment and to make that environment as stimulating as possible.

Conclusion

The research summarized here has been based on the assumption that creativity is to some extent a learnable cognitive skill, rather than an entirely inherited "gift" or talent. Many studies and experiments have substantiated this assumption by testing for different variables found to influence creativity. Some of these studies have suggested practical methods to help adults become more creative. Edward de Bono has developed techniques for stimulating lateral thinking; William J.J. Gordon coined the term "synectics" for his group problem solving techniques; and advertising executive Alex Osborn is credited with developing brainstorming as a method to generate new ideas.

Unfortunately, however, there has been little comparable work done for children. It has been shown here that children do in fact benefit creatively from certain kinds of play and play materials. But as yet, few existing play materials seem to be specifically directed towards developing children's creativity. From the research that has been examined, it would seem possible that there

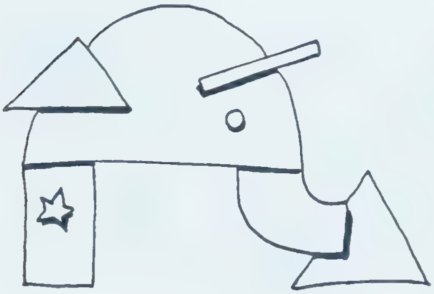
is room for a new class of play materials; one that does not neatly fit the existing categories of low or high structure toys, but instead combines aspects of both to offer a unique play experience in which creativity is actively encouraged.

Chapter 2: DESIGN CRITERIA

Design criteria for play materials which would stimulate creativity in children can be formulated by considering the play variables discussed in the previous chapter. Here, these criteria are grouped according to the play variables that they relate to.

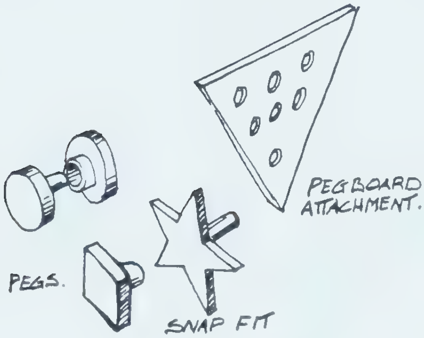
Play Variable	Design Criteria
pretend play	-pretend play should be encouraged through the use of materials that lend themselves to a variety of play themes
low/high structure	-generally preferred would be low structure materials that allow for multiple uses
	-possible inclusion of realistic materials to enhance the pretend play of younger children
construction	-materials preferred that can be recombined with other materials to construct a wide variety of objects
exploration	-exploration should be encouraged through the use of materials that provide: variability, novelty, surprise, uncertainty, conflict, choice
	-offer increasing levels of challenge and complexity
scale	-large, child-scale toys would seem to be most beneficial
	-in order to meet the criteria of complexity and variability, a variety of sizes might be indicated
type of supervision	-materials should provide an opportunity for the child to learn on his/her own, rather than requiring involved instruction or assistance from an adult
safety	-in keeping with the criteria of low supervision, materials should provide a maximum degree of safety requiring a

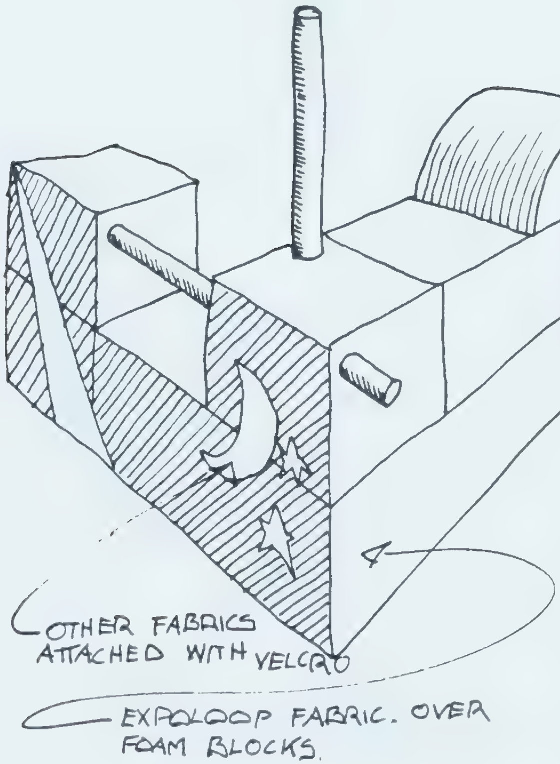
	minimum of adult observation
age range	-beginning at age three and continuing to at least seven years
market	-considering the projected complexity of these materials and their use for group play, daycare centres or community groups might be more appropriate potential clients than individual families
cost	-daycares (and families) are cost conscious and materials should be inexpensive and durable

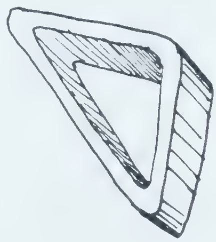


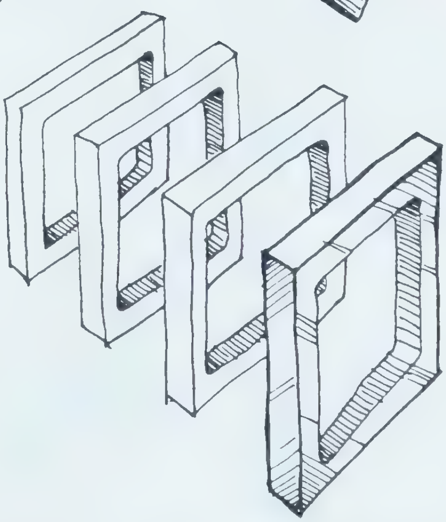
Chapter 3: CONCEPT DEVELOPMENT

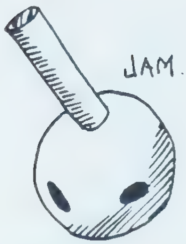
From the evidence presented and for reasons already outlined, it was felt that a group of widely diverse play elements with a variety of possible connections would be a likely direction for the design. This "family" of play objects might include: various materials, colours, and textures; different sized objects with varying degrees of complexity; a number of different connecting systems; "real" and abstract elements; shapes that would encourage a multiplicity of uses; non-referential objects that encourage exploration; large structural elements that could be used to construct environments; and a simplicity of design requiring minimum adult intervention.





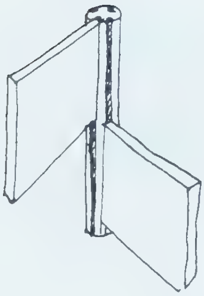


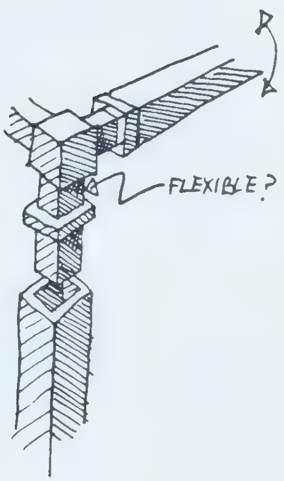


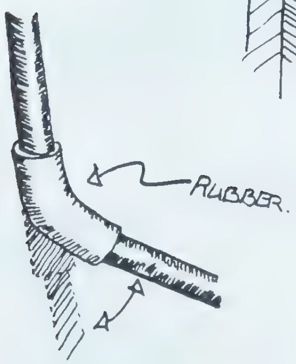


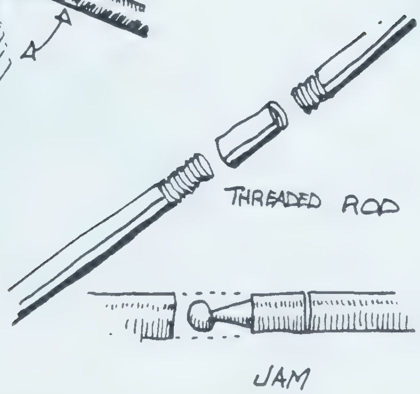
The sketches shown on these pages show an early identification of the problem of connecting dissimilar materials in a simple, flexible manner. The connecting system had to provide ease of assembly, a positive fit, flexibility to allow for movement and manipulation of the connected pieces, and choice; that given any two materials, a child could connect them in a variety of ways. Of these criteria, ease of assembly and disassembly by young children was considered the most important.

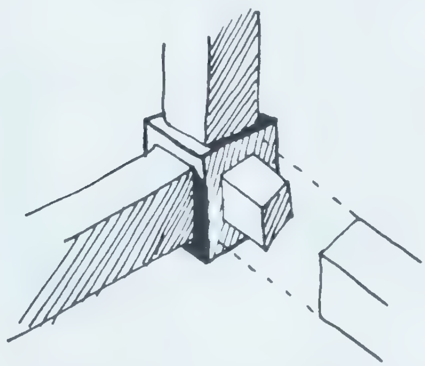
This requirement for ease of use necessitated the design of a simple connector that required little strength to assemble. Such a connector could not provide enough strength to allow resulting structures to be climbed on by children. However, climbability was considered irrelevant to the goal of stimulating creativity. In order to prevent children from climbing structures that might break under their weight, the whole system was made intentionally unstable. Because of the "weakness" of the connecting system and the flexibility of the tubes, constructed structures would fall apart or bend to the ground under <u>any</u> weight. In this way, no child would be able to get off the ground and be exposed to a potentially dangerous situation.

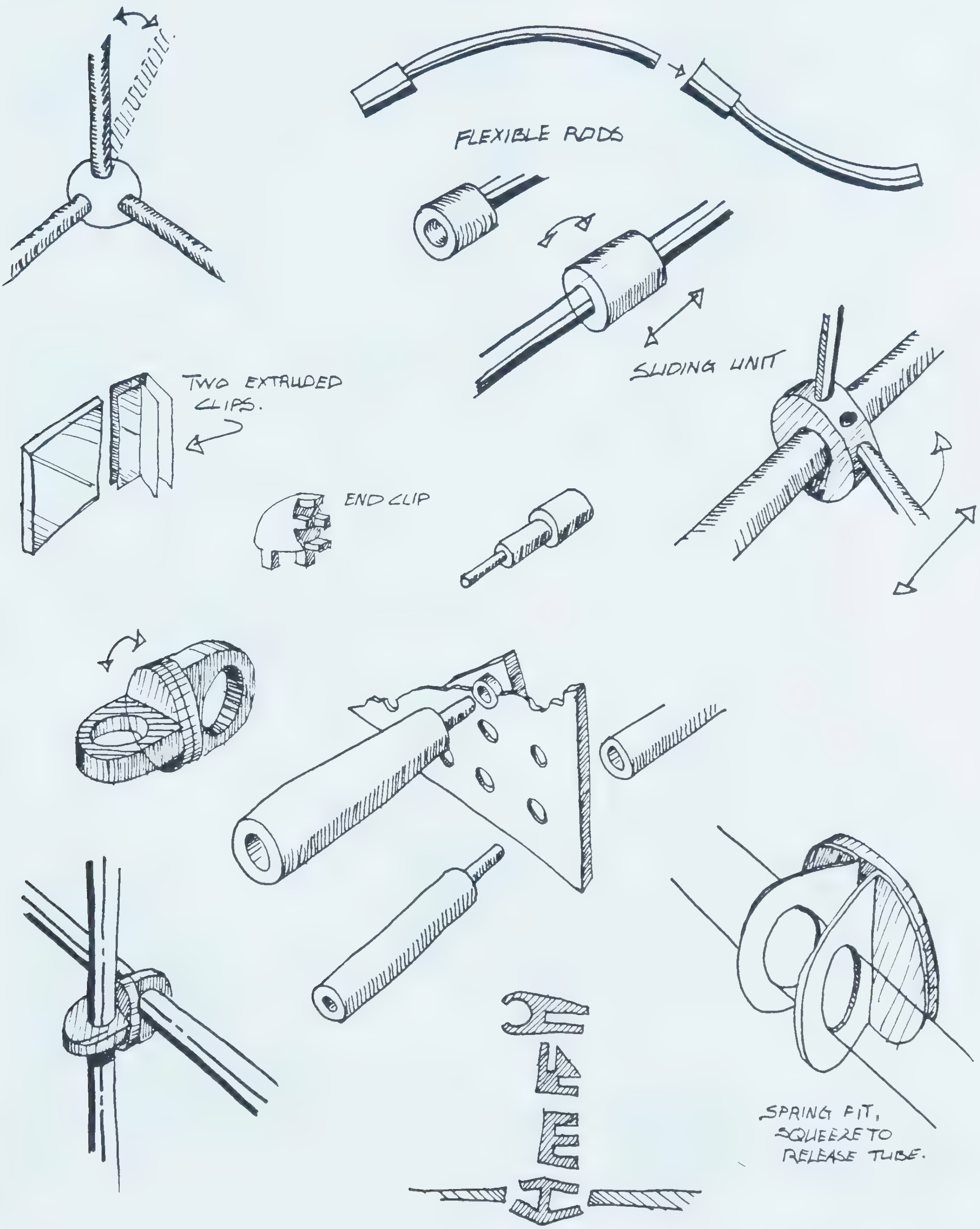








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CLIPS.
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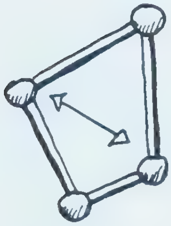
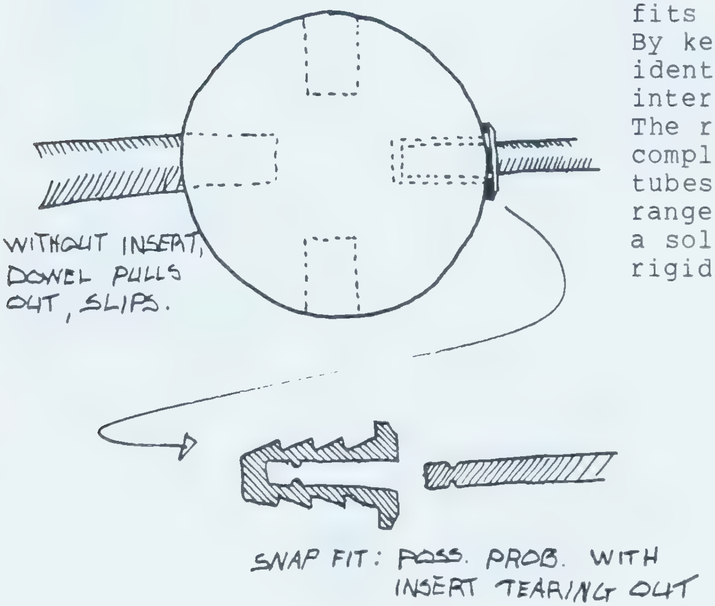
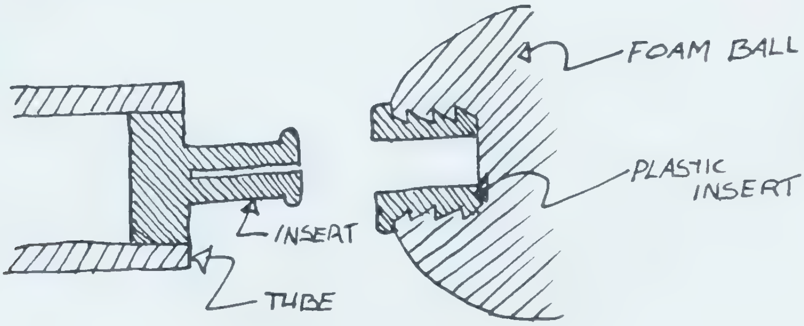
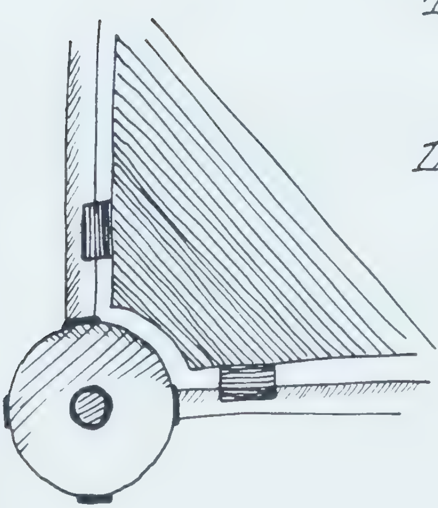
SLIDING UNIT
SPRING FIT,
SQUEEZE TO
RELEASE TUBE.

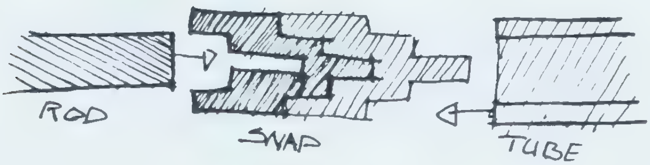


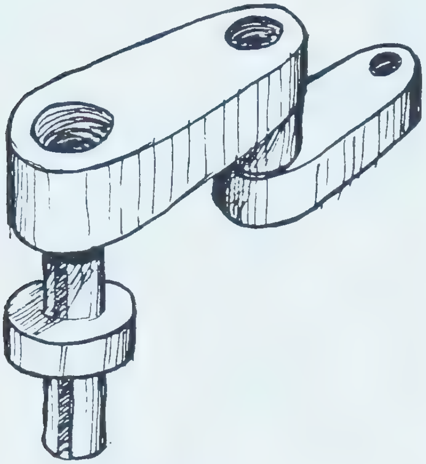
As the concept developed, it appeared that a friction fit connector, rather than a more complicated snap fit, or threaded assembly, would offer the best compromise between ease of assembly and the strength of connection. The basic connector finally chosen was simple: a tube fits into a corresponding hole. By keeping this connection identical in all pieces, complete interchangability was attained. The rubber ball connector is completely flexible and can attach tubes or sheets through a wide range of angles. The blocks give a solid fit. They join elements rigidly at a predetermined angle.

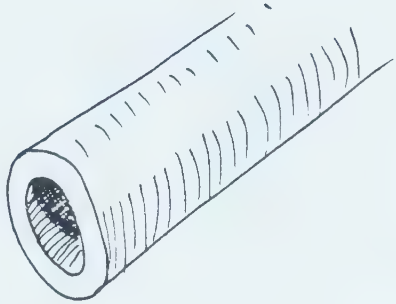


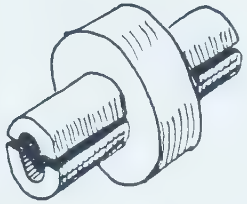


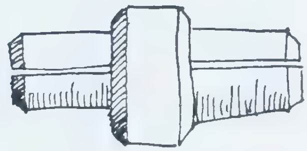


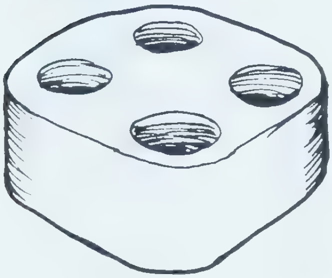


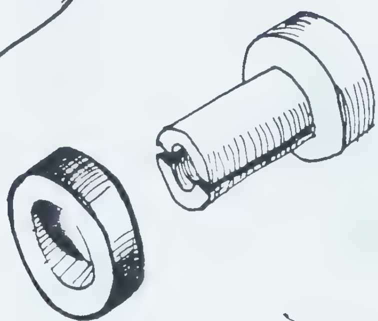


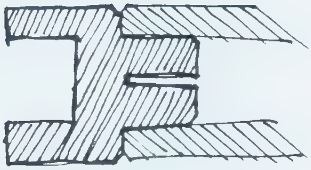


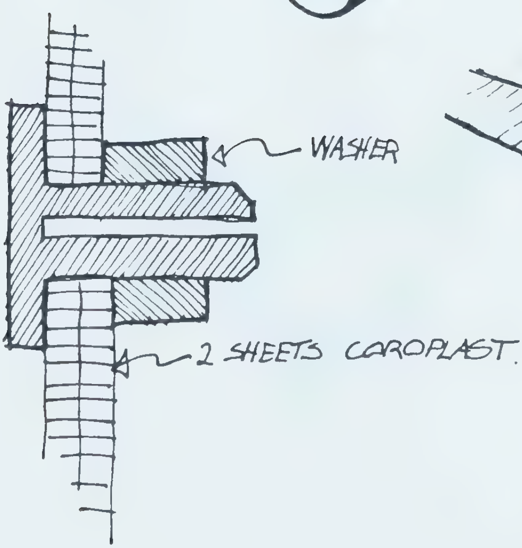


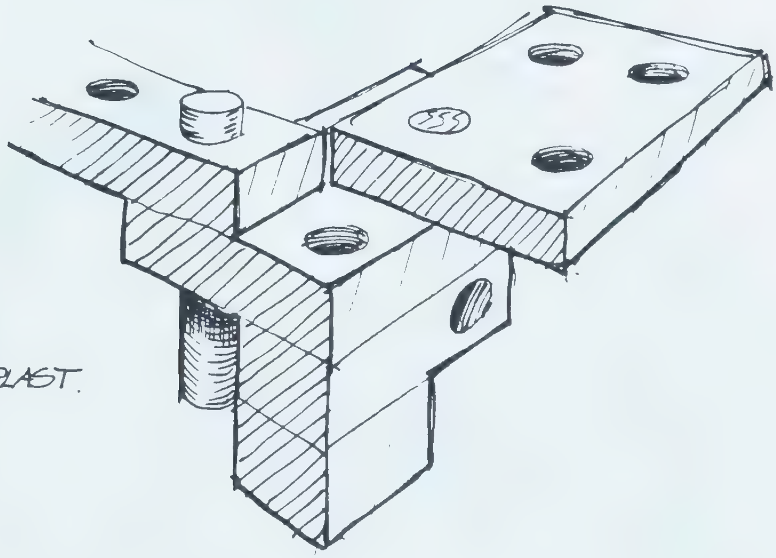


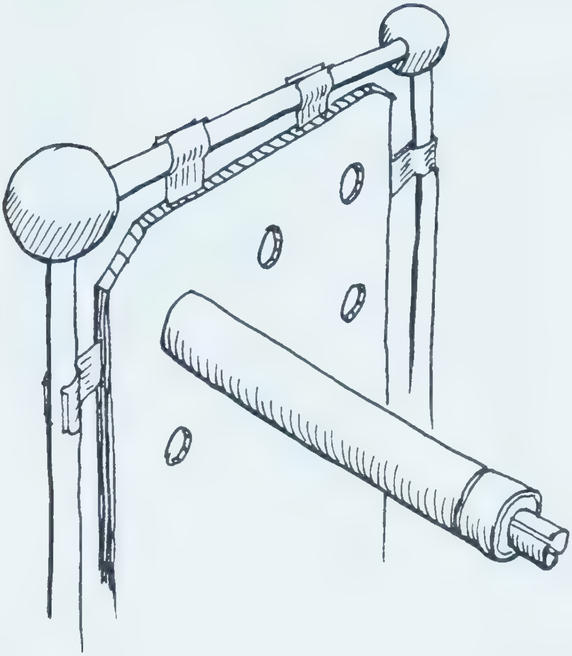




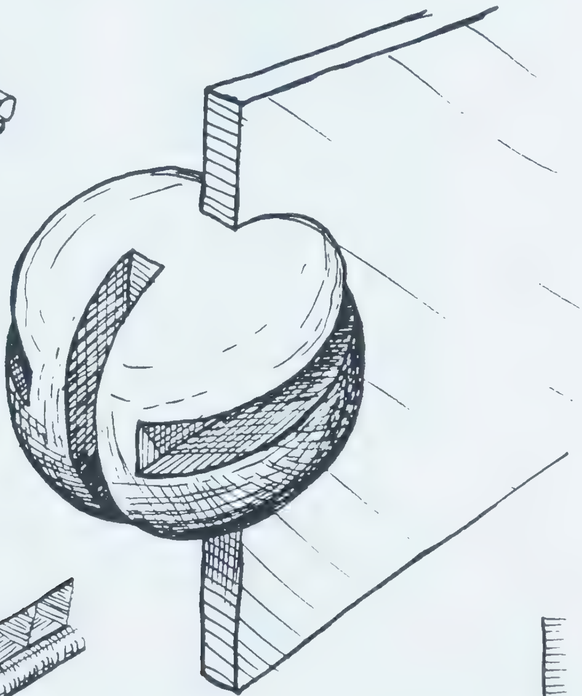


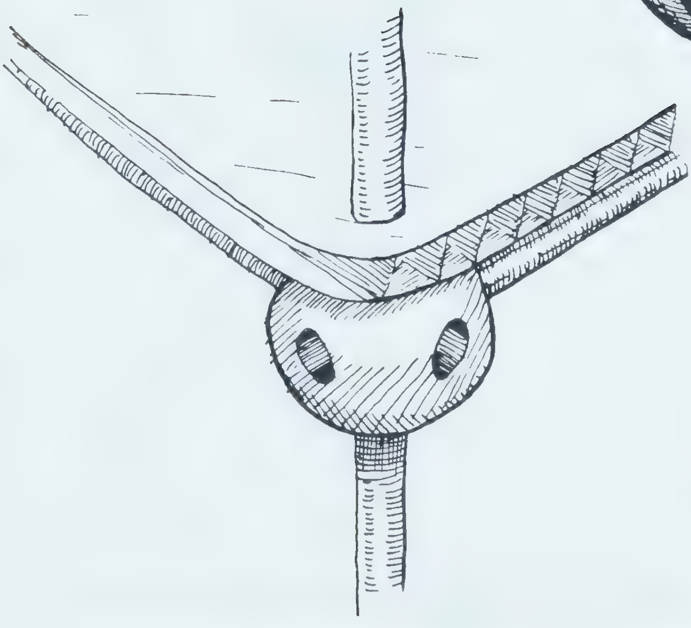

WASHER
2 SHEETS COROPLAST.

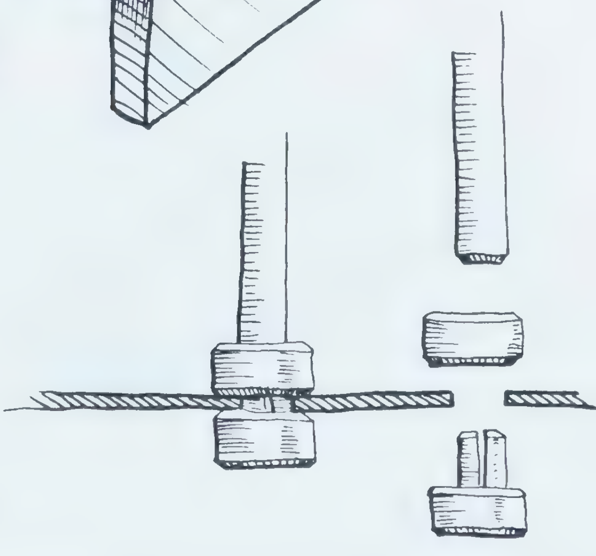


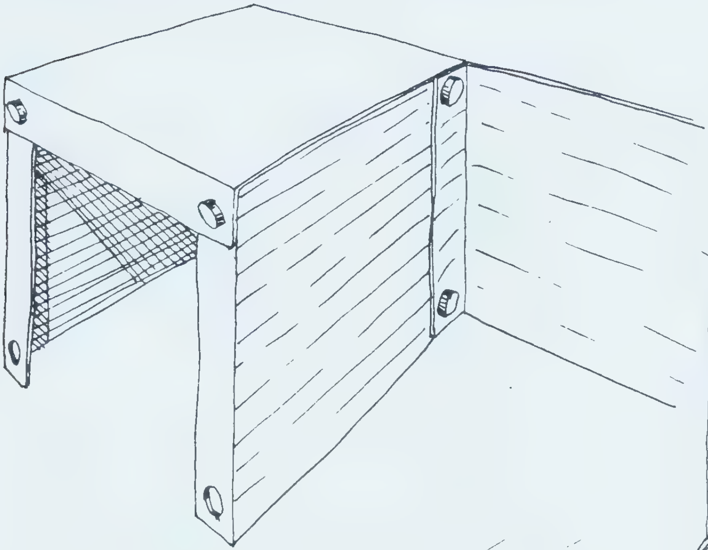


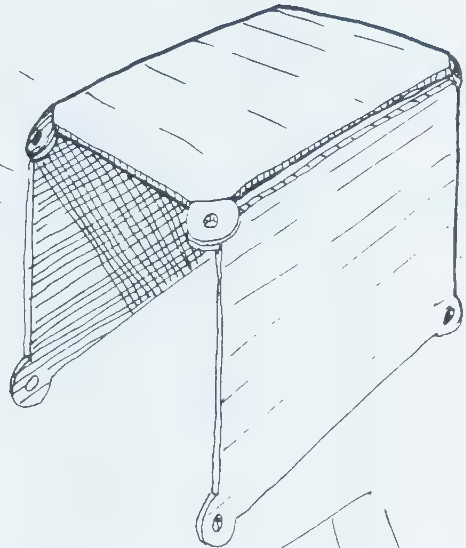
Adapting this simple connecting system for the attachment of one sheet to another proved difficult. Several add-on pieces were considered, until the method shown here was developed. The advantages of the folding corner are simplicity, ease of use, flexibility, and its conformity to the existing system. The chosen solution uses an add-on polypopylene corner, permanently fastened to the sheet.

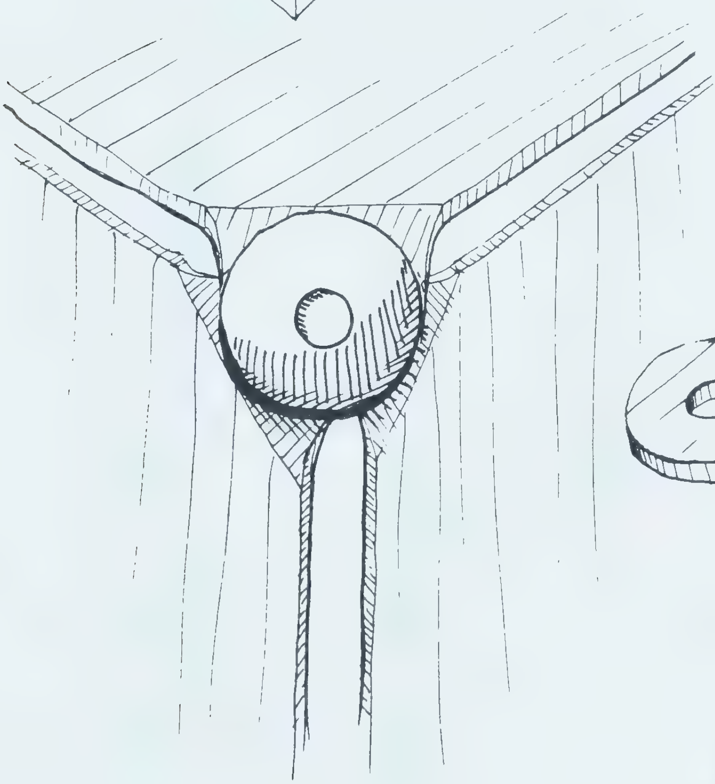


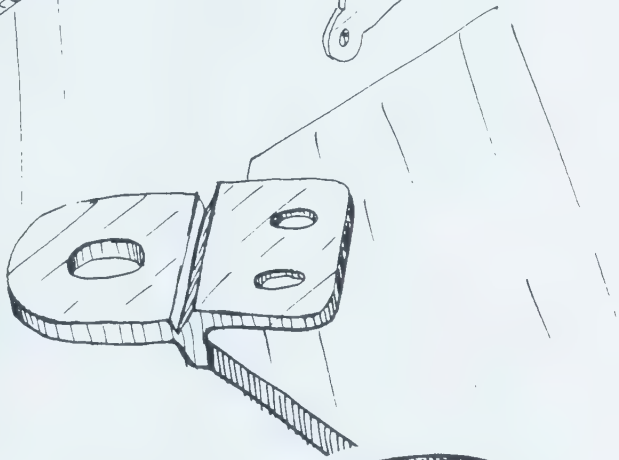


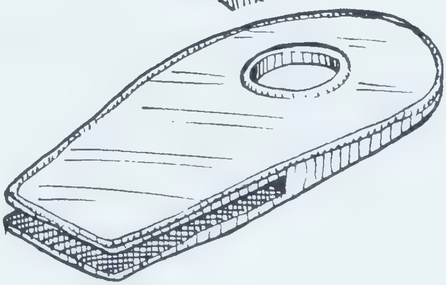


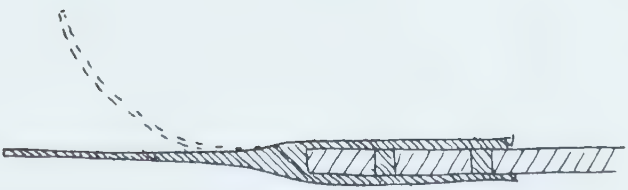


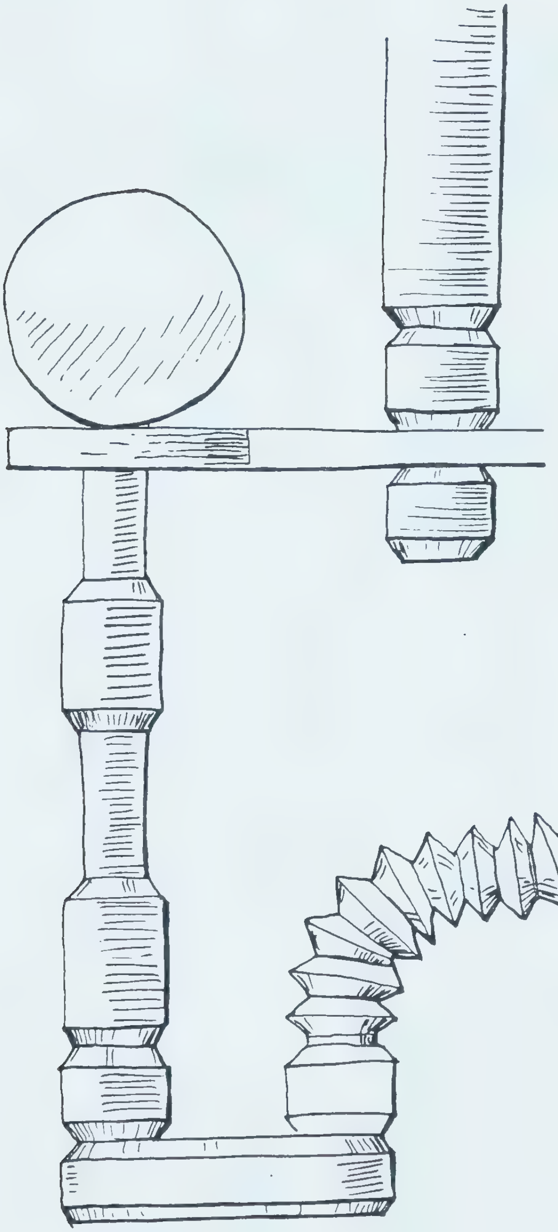




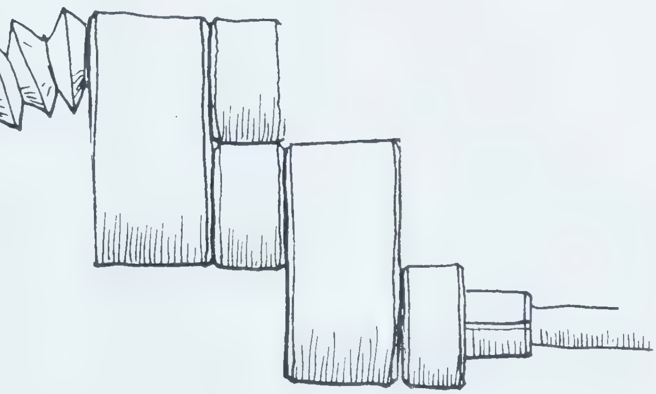


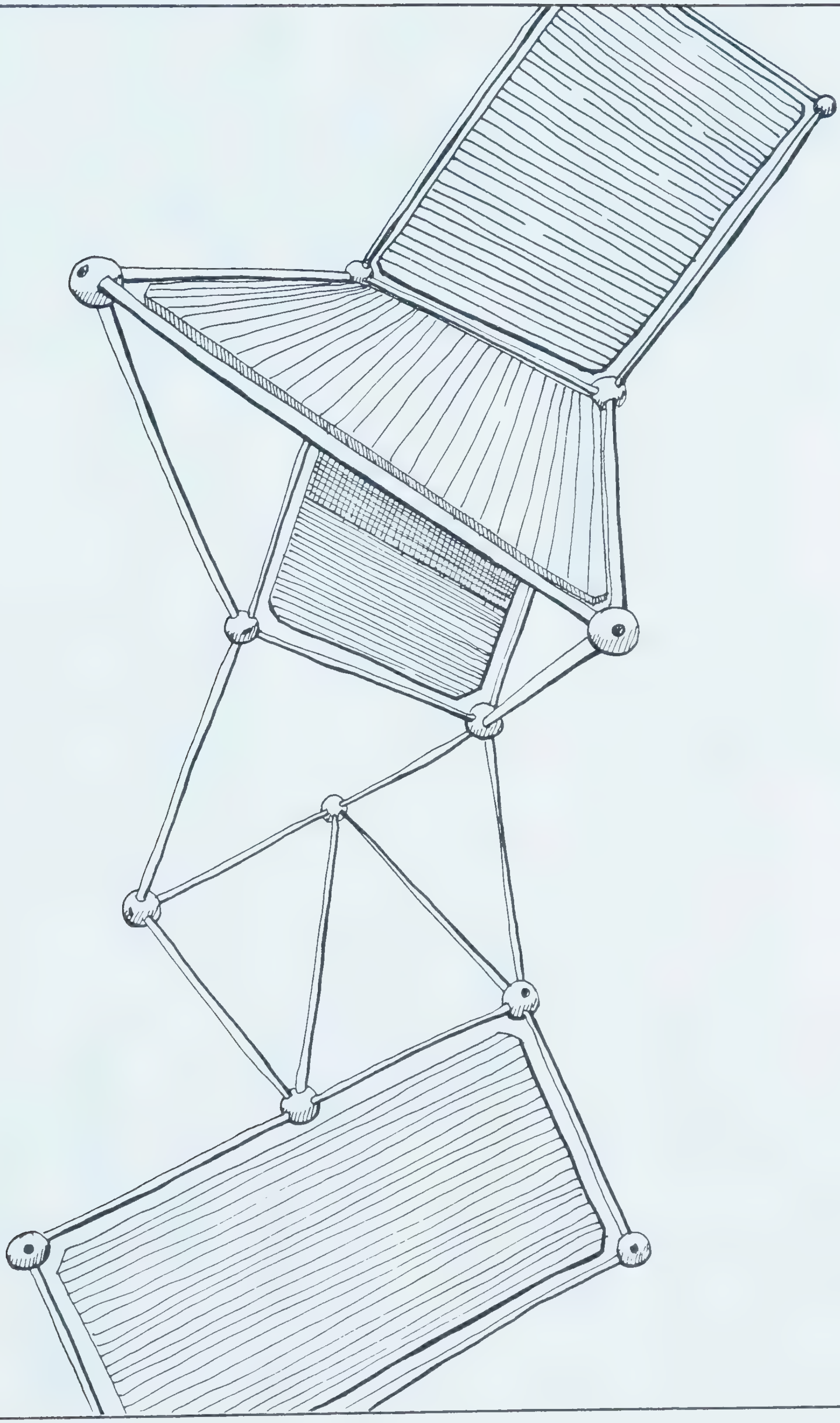


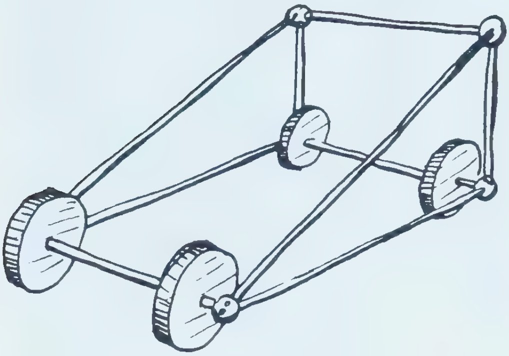




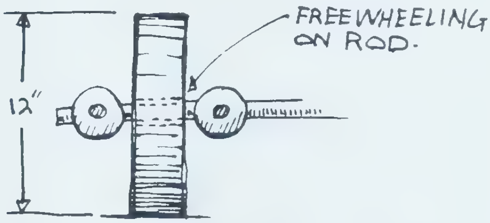
Scale was judged to be one of the most important design criteria. The ideal solution was felt to be elements with no predetermined scale; one that could be used to model larger objects in a smaller scale, used as life sized props in pretend play, to build large environments, or a combination of all three. In order to attain this ideal, different elements were designed: sheets, to enclose space; tubes of varying length, to be used as props, or to define open spaces; small blocks, to model other objects or to act as connectors for other elements; and rubber balls, for use primarily as connectors. Elements from all four groups could be used interchangeably. For example, a house large enough for a child to crawl into could be made of sheets connected with balls, and the furniture detailed inside with blocks and tubes. In this way, scale is a matter of choice by the child and not dictated by the elements themselves.

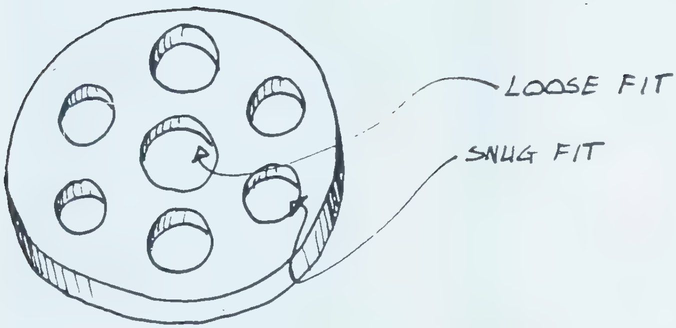


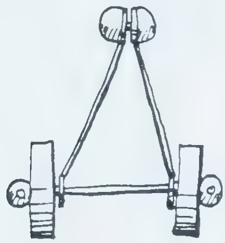


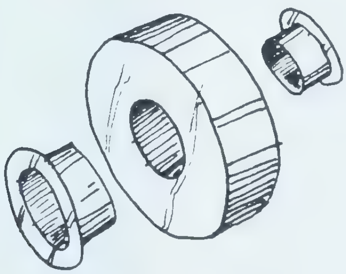


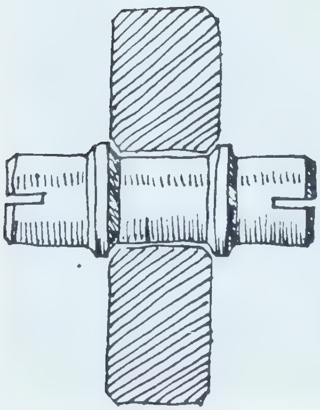
A final addition to the system included two sizes of wheels, one consistent with the small blocks, and the other with the large sheets. These wheels added the possibility of movement to the design in obvious ways, but their ambiguity allowed them to be used as simple disc shapes in more static configurations.

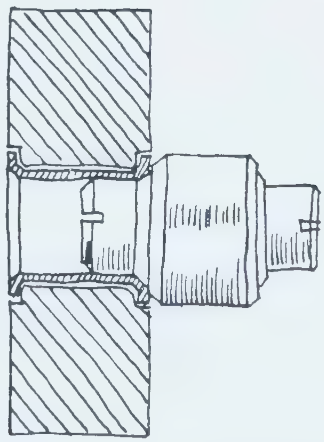


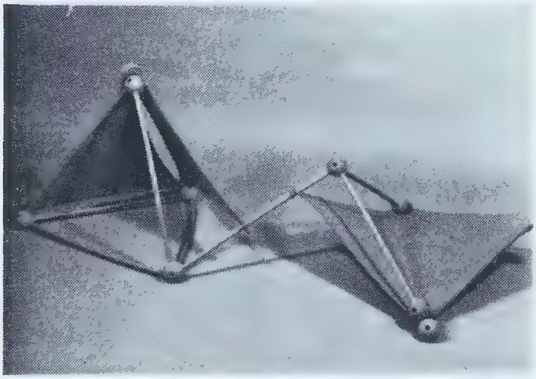


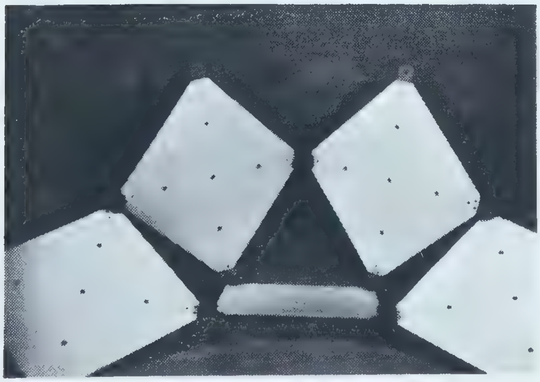












Chapter 4: PROTOTYPE

For testing purposes, a working prototype was constructed which duplicated, as closely as possible, the function of the final design. Materials were chosen for their desired properties, availability, and for their safety; either they were unbreakable or left no exposed sharp edges if they were somehow broken. Polybutylene and PVC pipe were used for the tubes and basic connectors, rubber balls for ball connectors, high density polyethylene for the blocks, foamcore and styrene for the sheets, and polypropylene for the corner connectors. In most cases, the materials chosen would be different in a manufactured version of the design (see Chapter 7).

Chapter 5: TESTING

The intention of the testing documented here, was to reveal any flaws in the design of the play materials or any problems in their use, to suggest the inclusion of any other elements or further design refinements, and, perhaps most important, to judge the acceptability of the materials relative to other play materials. These tests were informal and short term, but the desired information was attained.

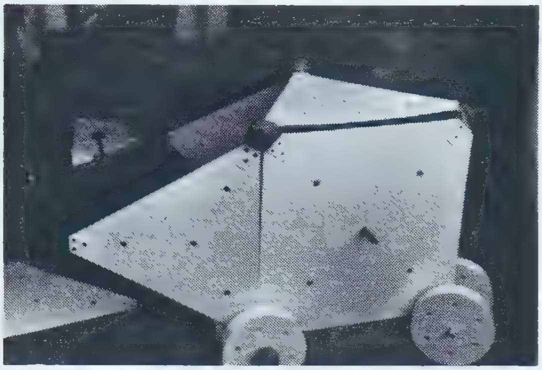
In all, eight groups of children were given the play materials for lengths of time ranging from twenty minutes to several days. The materials were divided into two sets: one set of the larger elements, including long tubes, sheets and large wheels; one set of the small connectors, blocks, balls, and short tubes. Groups were given the small system first, as an introduction, and then the large one,in some instances. The ages of the children given the materials ranged from two and a half to twelve.

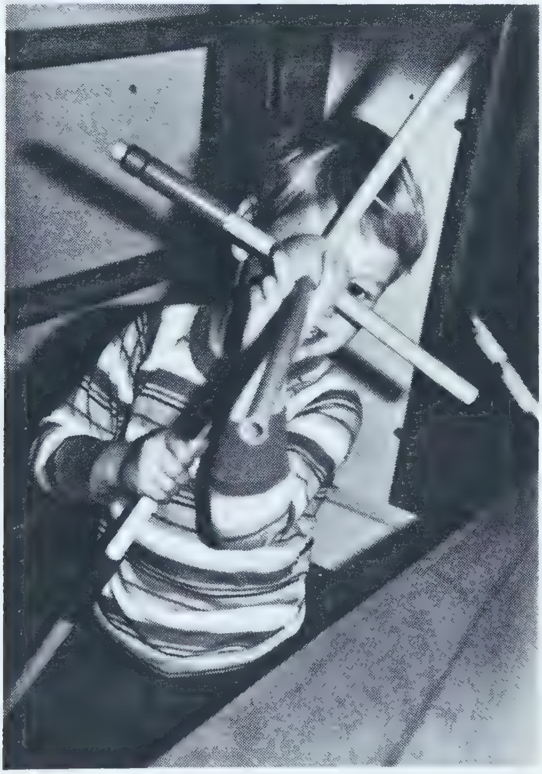
Groups Tested

SPRINGHILL NURSERY SCHOOL, Edmonton

- Group One: age 3, given small system only for one short test period (less than one hour)

- Group Two: age 4, given small system only for one short test period and both systems for another





GARNEAU SCHOOL KINDERGARTEN, Edmonton

- Group Three: age 5, given both systems in a one hour session and the small system only in another

STUDENT UNION DAYCARE, University of Alberta, Edmonton

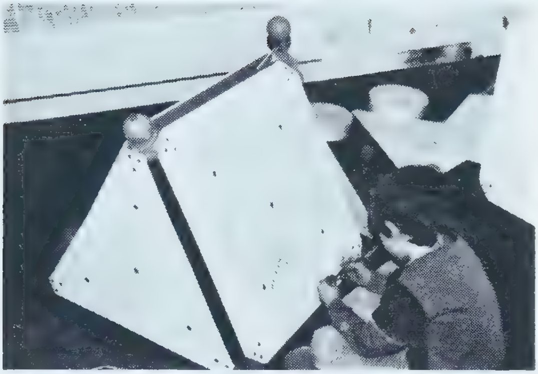
- Group Four: age 2 1/2, given small system for one short session
- Group Five: age 3, small system left with the children for two days
- Group Six: age 4, small system for one session
- Group Seven: age 5, given the smaller system initially for one day and both for three days after that

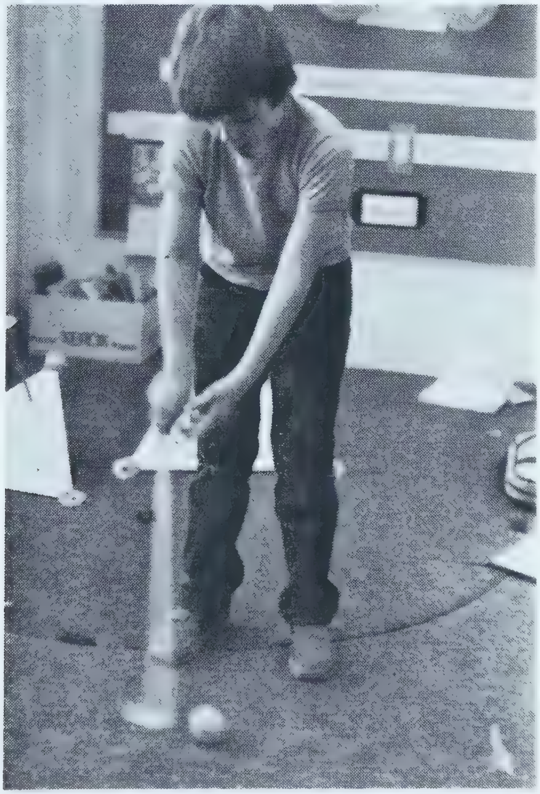
GARNEAU AFTER SCHOOL CARE, Edmonton

- Group Eight: age 6 - 12, given the large and small system for four days

Summary of Results

The youngest groups tested, two and a half to three year olds, had some difficulty with, and therefore little interest in, the large system. They had some problems physically manipulating the sheets and could not make the conceptual leap to use the small system to connect them. Some children also expressed difficulty in connecting some of the smaller

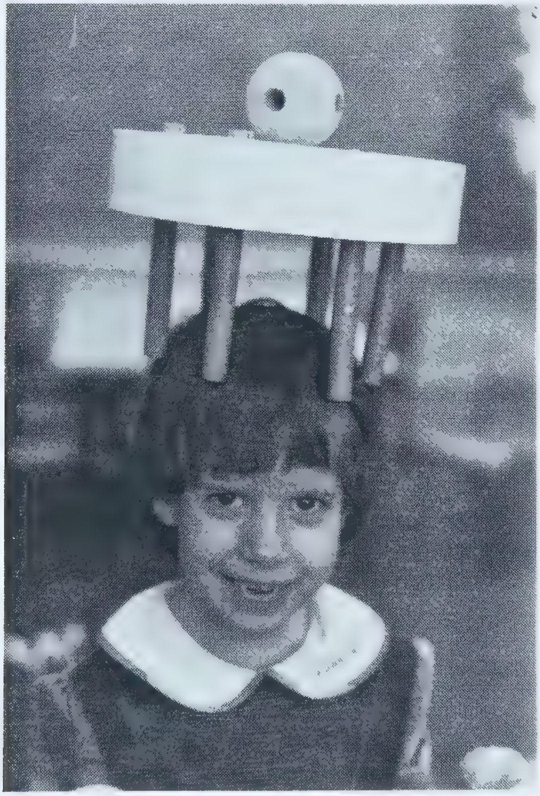




pieces (particularly with the balls), but most had little trouble. The children were initially enthusiastic about the materials, and this was maintained over two days. (A daycare worker said that there was always a race to play with them.) Objects built were often characterized by a linear quality, probably suggested by the linearity of the tubes themselves. There was much use made of the wheels, both in dynamic use, such as push-pull toys, and static use, such as the finger guard on a sword. Examples of constructed objects included lawnmowers, vacuum cleaners, microphones, and often purely abstract shapes with no stated function. These toys were often used as props in play.

Four and five year olds made more extensive use of both the large and small systems. They were able to manipulate them reasonably well, often in unexpected ways. The objects made were more complex than those made by the younger children, and more three dimensional. The materials were popular and the same children repeatedly played with them over several days. One group was given water soluble pens with which to draw on the sheets. These were used extensively to produce drawings which often related to the structures built (for example, a door and doorbell drawn on the side of a house).

The six to twelve year old group was extremely excited by the play materials and certainly the most creative in their use. Their interest was maintained for the duration of the available time (two hours after school) and for the full week the materials were left there. Initially, objects built were quite simple, but as the week progressed they became



increasingly complex and original. However, there was little use of the small washer type connectors, and almost no use of the corner connectors as they were intended to be used. Even after their proper function was demonstrated, few children explored the possibilities of the flexible corners to create large structures. This might have been due to the fact that the prototype corners were slightly stiffer than they should be and did not bend easily. But a more likely explanation is the rather frantic nature of an after school care program. The time available is short, and the children were quite active after a day of school. In a home or another setting where there is a more extended period to examine the materials and an opportunity to come back to work on structues left over from the day before, it is felt that the corners would be used to their fullest potential.

Conclusion

The design was judged successful by enthusiastic parents, day care workers, and of course, by children. The design seemed to fill a gap in the toys available to the children as no other toy offered such a wide range of possibilities. It was this aspect that appealed most to the day care workers as well as the safety of the materials.

Although this testing did not give empirical evidence of the materials' ability to foster creativity, there is subjective evidence of their effectiveness in stimulating creativity. By examining the design in light of the initial working definition of creativity, "Creativity is the

production of novel responses that have an appropriate impact in a given context" (Jeanrenaud and Bishop, 1980), it is clear that these materials have been used creatively. The ambiguity of the pieces and their connectability strongly encourage the production of novel responses, and their appropriate impact is seen in the use of the constructed objects by the children in their play. All of the childcare workers involved attested to the creative use of the materials by the children, and further, claimed that the materials encouraged that response from the children. The persistence of the children in using these materials to make objects of their own devising attests to their popularity. Finally, since the design criteria for these play materials were established by identifying the play factors which affected creativity positively (see Chapter 1: Summary of Research), then the final design should stimulate the development of creativity in children. Testing has effectively indicated that the desired characteristics of play materials which promote creativity are evident in the system designed.

Chapter 6: FINAL DESIGN

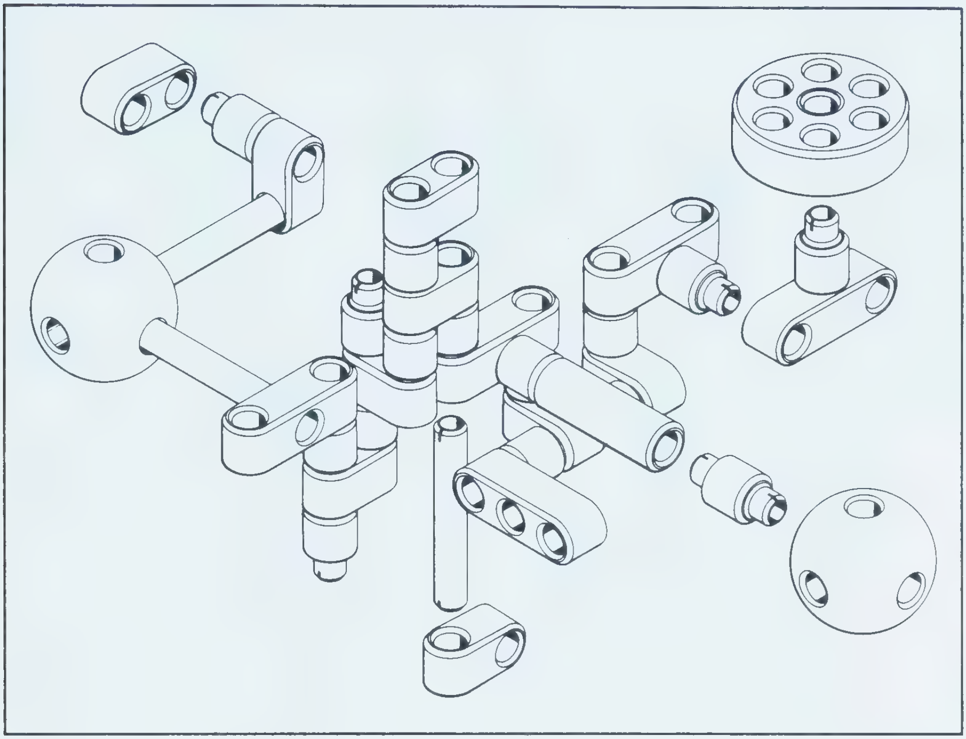
The following pages include assembly drawings and working drawings of the final design. The design has remained the same as the original prototype except for minor changes. These are:

- The dimensions of the basic connector and blocks have been slightly increased to fulfill the requirememts of the Ministry of Consumer and Corporate Affairs for the design of toys for children under the age of three. While this design is intended for older children, it was felt that this small design change gained a major advantage in safety. Younger siblings will not choke on the new, larger pieces.

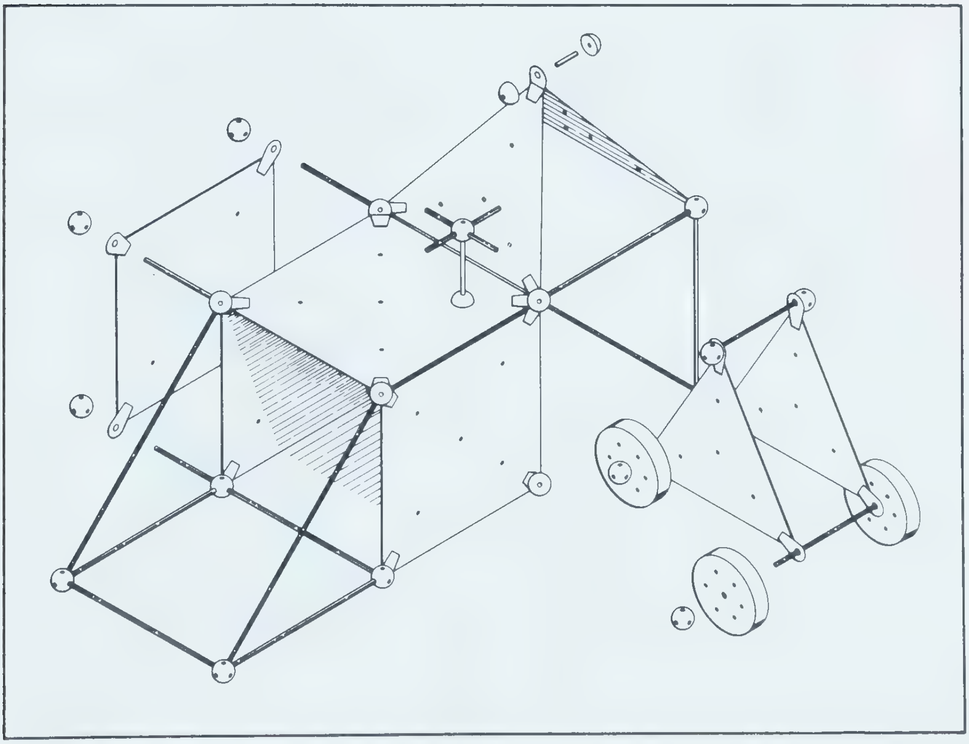
- The small washer connector was discarded for three reasons: it provided a weak connection, it was seldom used, and it was too small to meet government requirements (see above).

- The corner connectors were thinned slightly, making them even more flexible, thereby overcoming the stiffness of the corners in the first prototype.

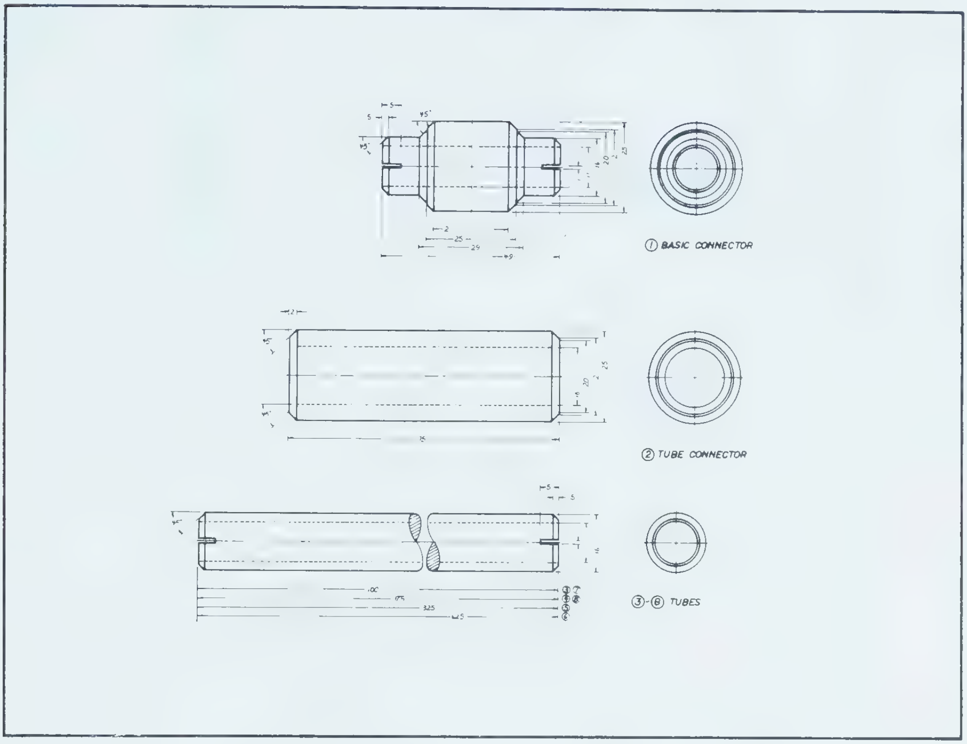
- The axle of the small wheel was redesigned to avoid the misperception that it came apart, as was the false impression given by the working prototype.



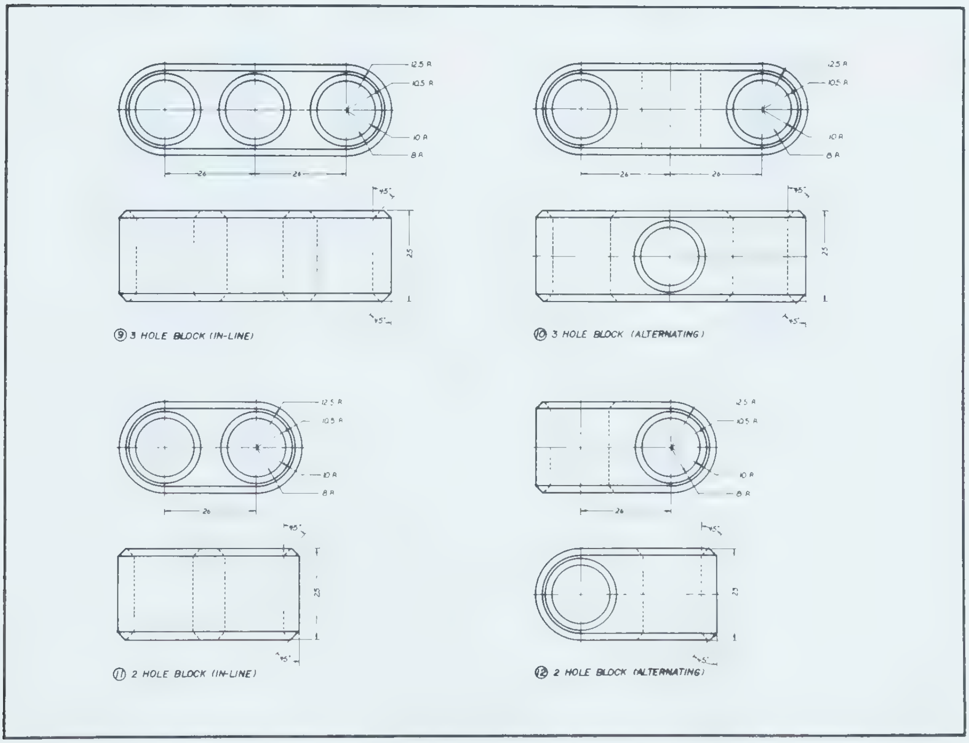
Assembly view:
small system



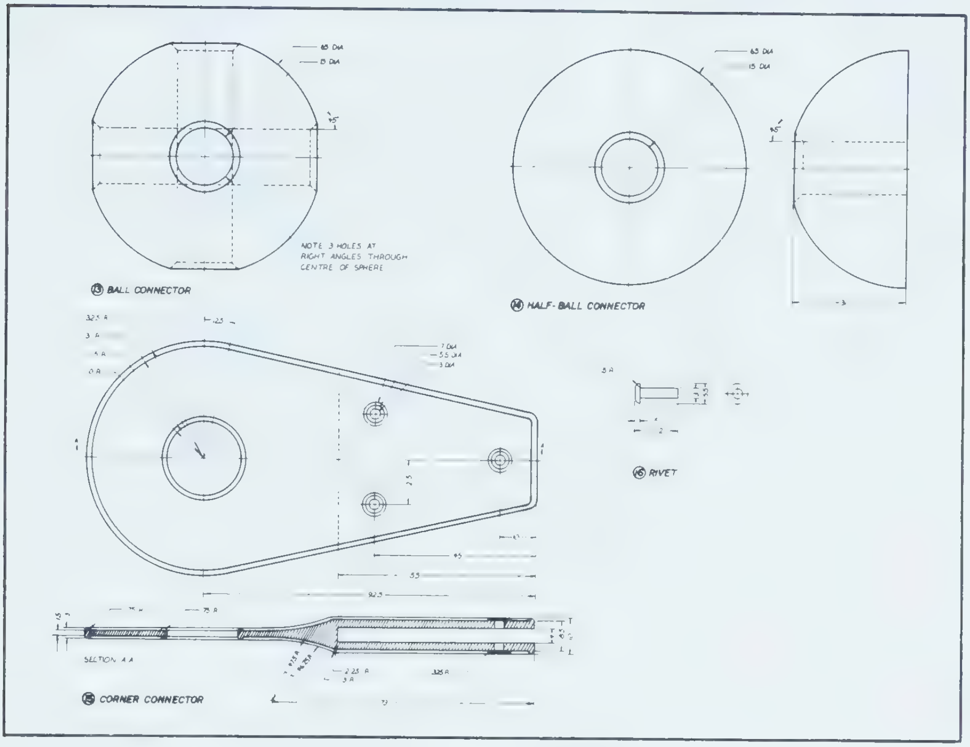
Assembly view:
large system



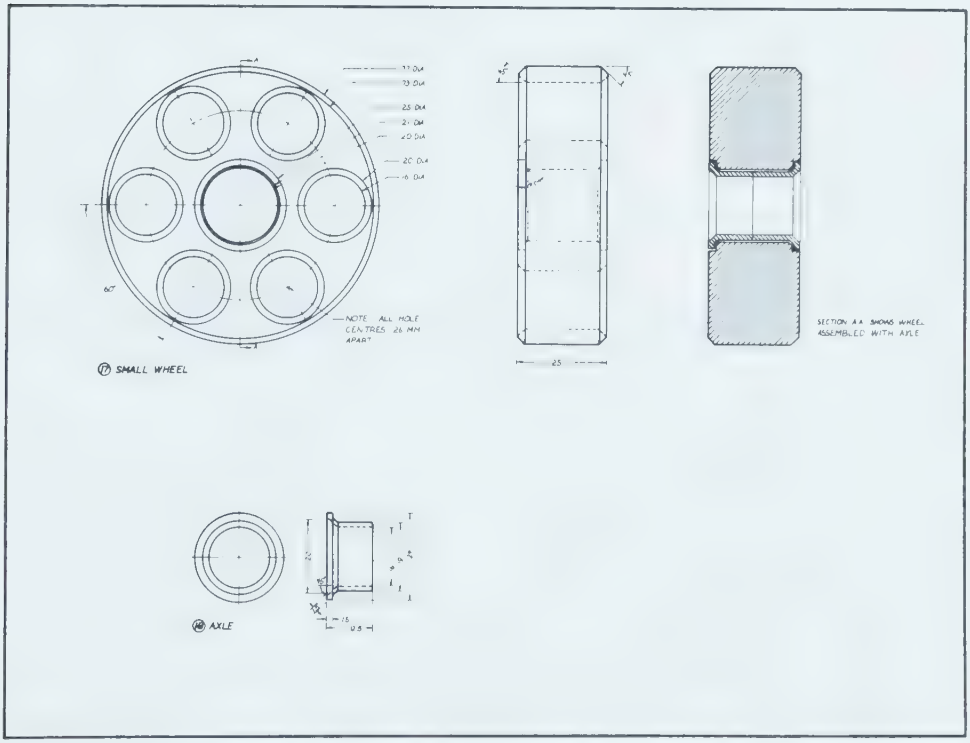
Orthographic: basic connector and tubes



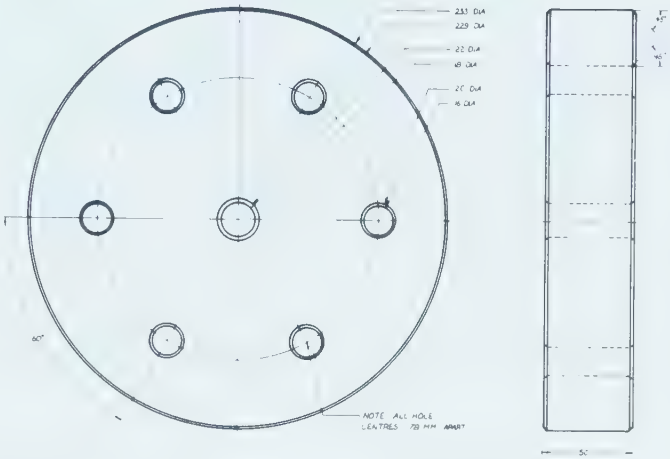
Orthographic: blocks



Orthographic: ball, half-ball, and corner connectors

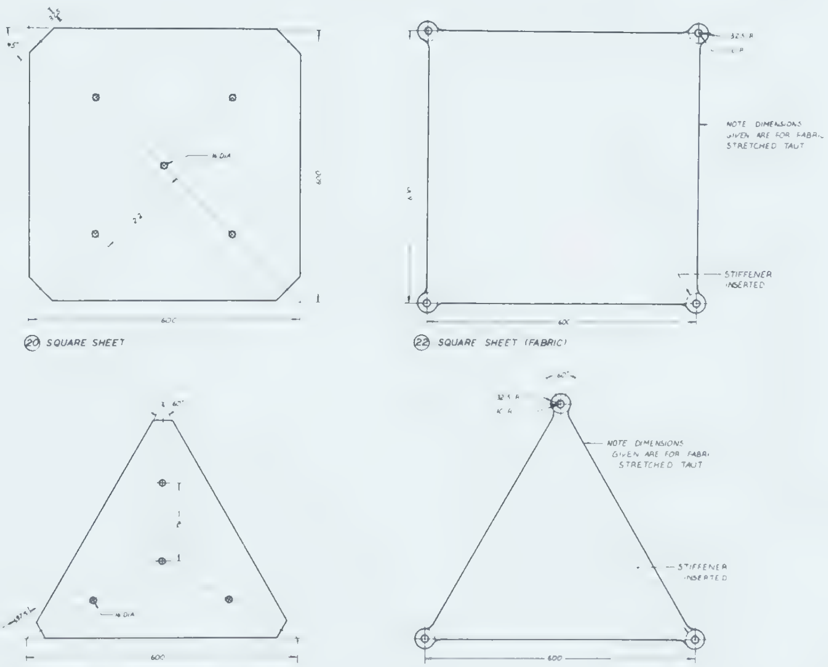


Orthographic: wheel (small)



(19) LARGE WHEEL

Orthographic: wheel (large)



(20) SQUARE SHEET

(22) SQUARE SHEET (FABRIC)

(21) TRIANGULAR SHEET

(23) TRIANGULAR SHEET (FABRIC)

Orthographic: sheets

Chapter 7: MANUFACTURE

The manufacture of these play materials takes advantage of the materials and processes of plastics technology. Several different plastics are specified; each lends its own specific properties to the component for which it is used. ABS is specified where accuracy of fit and durability are required. Polypropylene is recommended for the corner connectors and the tubes for its ability to bend repeatedly without breaking. Low density polyethylene is specified for some of the tubes to provide a flexible, hose-like component. The ball connectors are to be manufactured of a foamed latex, to allow for flexibility. The sheets are constructed of styrene and foamcore, to give rigidity, strength, and lightness. The manufacturing techniques specified depend on large scale mass production to make them economically feasible. A complete list of parts with the materials and the manufacturing techniques specified for each are outlined below.

No.	Part	Material	Manu. Process
1	basic connector	ABS	injection molded
2	tube connector	ABS	injection molded
3-6	tubes (dif. lengths)	polypropylene	extruded
7-8	tubes (dif. lengths)	low density polyethylene	extruded
9-12	blocks	ABS	injection molded
13-14	ball connectors	foamed latex	slush rotation molded
15	corner connector	polypropylene	injection molded
16	rivet	styrene	injection molded
17	small wheel	polypropylene	injection molded
18	axle	ABS	injection molded
19	large wheel	ABS	rotation molded
20-21	sheets	foamcore, styrene	laminated, punched, or cut
22-23	sheets	stretch fabric	sewn

Costs

At this stage of design, costs are difficult to determine precisely. However, from a consultation with Charles Robertson, an instructor in plastics technology at the Northern Alberta Institute of Technology, a rough idea of costs can be projected.

Manufacturing costs are determined by three variables: mold cost, cycle time, and material cost. Robertson estimated that a mold for the basic connector and two blocks, ganged up for a total of ten units, would cost about $30,000. He estimated a cycle time of 30 seconds, with machine time costing $100 per hour. Material cost for ABS was estimated at $.65 per pound. Based on these figures, a cost per unit can be calculated as follows:

No.	Mold CPU*	Time CPU	Mat. CPU	Total CP
10,000	$3.00	$.08	$.04	$3.12
100,000	$.30	$.08	$.04	$.42
500,000	$.06	$.08	$.04	$.18

*CPU - cost per unit, 10 units per mold

As can be seen from the above chart, time and material costs are fixed, but the mold cost per unit is drastically reduced as the number of units manufactured is increased. At 500,000 the basic unit cost becomes quite low, certainly competitive with other plastic construction toys.

Using this figure of $.18 per unit as a guideline, costs for the other components can be roughly established. From these basic costs, a general idea of the final manufacturing cost of one large set of the play materials can be arrived at.

Part	Total CPU	Quantity	Total Cost
basic connector, blocks	$.18	150	$27.00
tube connectors	$.30	50	$15.00
tubes	$.50	100	$50.00
ball, half balls	$.50	100	$50.00
corner connectors	$.50	50	$25.00
sheets	$2.00	12	$24.00
TOTAL MANUFACTURING COSTS			$191.00

Chapter 8: MARKETING

The body of research summarized in Chapter 1 seemed to indicate that an appropriate age range for creative play materials would be three to seven years. Rubin (1983) claimed that at the age of seven, creative play with materials tended to evolve into games with rules. However, informal testing of the thesis project did not support this claim. In fact, children up to the age of twelve were found to play creatively with the materials and no games with rules were observed. This indicates a target user group of children from the ages of three to twelve.

The actual buyers of toys for children in this age group fall into two categories, families and institutions. Although adult family members (parents, grandparents) account for the largest share of the toy market, in this case they are not considered the primary market. The number of components necessary to make the play materials appealing is high, and the cost therefore expensive, relative to other commercially available toys. Smaller kits could be packaged for this market, but from the information obtained through testing, it would be difficult to determine the ideal quantities and ratios of components. This market might become more feasible at a future date.

Day Care Centres, on the other hand, offer an immediate and more realistic market. A report on daycares by the Ministry of National Health and Welfare (Social Service Programs Branch, 1984) recommends that equipment start-up costs for a daycare with 15 to 20 children would be at least $7,000 to $10,000. It uses the term "equipment" to refer to furniture and larger, durable play materials. The manufacturing cost of $191.00 for this design (see previous chapter) translates to roughly $800.00 at the retail level. This figure falls well under the recommended guidelines and compares reasonably with other play systems that are currently bought by daycares.

The daycare market in Canada is well established. In Edmonton alone there are 231 licensed daycare facilities serving 9,762 children, with an average 42 children per facility. Nationally there are 149,965 licensed spaces for children (Cooke 1986). Based on the Edmonton average of 42 children per daycare (Cooke lists no national number of facilities), there may exist approximately 3,570 daycares in Canada. At $800 per unit, one unit per daycare, the potential market in Canada for the play materials is currently $2.8 million. This figure will increase as the number of daycare facilities rises to meet the expanding need for child care.

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SLIDE LIST

Conceptual Sketches

1-8) Samples from sketchbook showing design development

Working Prototype

9) Basic blocks

10,11) Blocks assembled with tube connectors

12) Small wheels

13) Assembled structure showing use of several different connectors

14) Ball and half-ball connectors

15,16) Balls assembled with block and tube connectors

17) Sheets

18) Detail of corner connector

19,20) Structure showing possibilities of assembled sheets

21) Large wheels

22) Assembled structure showing use of wheels with sheets, tubes

Testing

23-32) Examples of constructed structures by children during testing of the thesis project

Final Design

33,34) Assembly view, large and small systems

35-39) Final working drawings